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The Honorable John Conyers, Jr.
Chairman, Subcommittee on Legislation
and National Security
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

This report responds to your February 27, 1989, request that we evaluate the Army's acquisition procedures for the procurement of a tank recovery vehicle. The report addresses your questions concerning (1) what criteria the Army used to make its selection of one of two competing vehicles; (2) whether the M88A1E1 (the winning vehicle) meets the Army's established requirements for a recovery vehicle as defined in its system specifications; (3) whether the Army's requirements are stringent enough to meet its mission needs; (4) whether tests of the vehicles were conducted realistically; and (5) how many of these vehicles the Army plans to buy and how much they will cost.

The results of our review are summarized in this letter, and the Army's evaluation process and test results are discussed in appendix I. Our objectives, scope, and methodology are discussed in appendix II.

Results in Brief

The Army tested two competing recovery vehicles, one developed by the BMY Division of HARSCO Corporation and the other developed by the General Dynamics Land Systems (GDLS) Division. Recovery vehicles are designed to maneuver with armored battalions and perform the three main functions of towing, lifting, and winching disabled tanks. The Army used six selection criteria to evaluate the two vehicle candidates. It tested the vehicles at Aberdeen Proving Grounds in Aberdeen, Maryland, where the Army has attempted to approximate ground and terrain conditions generally found in Germany.

The Army determined that both vehicles would meet its recovery vehicle requirements, but each had operational deficiencies. In December 1988 the Army selected BMY's M88A1E1 to continue in full-scale engineering development because of its lower cost. However, in the revised fiscal year 1990 budget, the Department of Defense (DOD) proposed terminating this program. Even so, the Army still has a requirement for 849 vehicles. It had planned to buy 276 through fiscal year 1994 at an

estimated cost of $416.3 million, but now the program's future is uncertain.

During its evaluation of the two vehicle candidates, the Source Selection Evaluation Board (SSEB) questioned whether the M88A1E1 could keep up with the Abrams (M-1) tank force it was intended to support during convoys, lateral movements, and high-speed deep penetrations. The BMY vehicle also failed to meet one of the technical specifications, which called for towing an M-1 tank up an unpaved 30-percent slope. Although the SSEB viewed the slower speed of the M88A1E1 as a limitation to its ability to carry out its mission, the SSEB determined that the vehicle sufficiently met the performance requirements to continue in full-scale engineering development. Although the Army decided to continue full-scale engineering development with the M88A1E1, it had not completed a required cost and operational effectiveness analysis (COEA), which could have helped to assess the impact of the system's speed limitations on its operational effectiveness. If the Army decides to continue its tank recovery vehicle program, further testing could demonstrate whether the M88A1E1 will allow the Army to recover M-1 tanks in circumstances where the current system has difficulties.

Background

The current recovery vehicle, which was originally fielded in 1961, weighs 56 tons and has only 750 horsepower. It does not have the traction or the power to tow tanks weighing 60 tons or more over unpaved slopes, and it must work in pairs to safely tow these tanks. With the growth in weight of the Army's main battle tanks to 65 and eventually to 70 tons, the Army determined in 1981 that it urgently needed an improved recovery vehicle. In fact, for the last several years, the need for a new recovery vehicle has been on the Army's list of top 20 battlefield deficiencies.

The Army considered two options for replacing its recovery vehicle. One option was to develop a new vehicle called the "RV-90," with higher performance capabilities than the current M88A1. Specifically, the RV-90 called for a non-towing speed equivalent to the speed of the M-1 tank. The second option was to develop an improved version of the M88A1. This vehicle would be heavier and more powerful so that it could recover the heavier tanks, but it would be slower than the RV-90. In 1985, the Army chose to improve the M88A1 because it could be fielded in less time and at substantially less cost than the RV-90. At that time, lower cost and an earlier fielding date were considered more important than obtaining higher speed. In January 1987, the Army

awarded a development contract to BMY, the manufacturer of the M88A1 recovery vehicle, for engineering design and development of the improvements. In the meantime, however, GDLS had independently developed a new recovery vehicle based on the M-1 tank chassis, and the Army began to consider this vehicle as a second candidate to meet its requirements.

Various Congressional Conference Committees in 1987 directed that the two available vehicles be tested and that a report be submitted to the Congress regarding (1) required operational capabilities, (2) the adequacy and accuracy of competitive testing, (3) the cost-effectiveness analysis of the two vehicles, and (4) the determination of which candidate vehicle the Army would procure.

The Army conducted the side-by-side test of the two vehicles between April and July 1988, and in December 1988 it informed the Congress that it had selected BMY's recovery vehicle to continue full-scale engineering development. The Army did not send a report to the Congress, however, because it had not decided to procure the M88A1E1.

Selection Criteria and System Deficiencies

The Army evaluated the competing contractors and systems in the following six areas (in order of assigned weight): technical performance, operational suitability, cost, man/machine interface, logistics, and production capability. The SSEB determined that both candidates met the Army's recovery vehicle requirements. The GDLS candidate was rated higher in terms of horsepower and speed. The BMY candidate was considered more affordable by the Army and was selected to continue full-scale engineering development. While BMY's vehicle was able to tow M-1s down slopes unassisted by an additional tow vehicle, the Army believed that there were still developmental problems to overcome before committing itself to a production decision.

While the Army determined that BMY's vehicle would essentially meet its recovery vehicle requirements, it identified the need for corrective action in several areas, including the main and auxiliary winches, the cooling system, reliability, and uphill towing. Citing concern over vehicle deficiencies revealed during testing, the Army decided in December 1988 to extend full-scale engineering development to correct the problems before any production monies were released. The contractor has planned corrective actions on the identified deficiencies except in the area of uphill towing. Follow-on testing could verify whether these

actions have solved the problems and settle disagreement over the uphill towing test results.

Concerns About the M88A1E1's Speed and Uphill Towing

Concerns raised by the SSEB about the M88A1E1's marginal speed performance and uncertainty regarding the results of the uphill towing during technical tests make it difficult to determine whether the M88A1E1 meets the Army's mission needs. Even if the vehicle satisfies the Army's performance requirements for a tank recovery vehicle (as defined in its contract specifications), the requirements themselves may not be stringent enough to meet the Army's mission needs. For instance, while the vehicle may be fast enough to meet the Army's technical performance requirements, the required speed may not be sufficient to meet the Army's mission needs. Conversely, if the vehicle does not satisfy certain of the Army's requirements, this does not necessarily mean that the vehicle does not meet the Army's mission needs. For example, if the recovery vehicle cannot tow an M-1 tank up a 30-percent slope but there are few mountains with 30-percent slopes where this vehicle is to operate, its inability to meet the Army's requirements will have little impact on the accomplishment of its mission.

The SSEB questioned whether the M88A1E1's slower speed will limit its ability to keep up with the more mobile and agile combat force it is intended to support during high-speed maneuvers. The SSEB was concerned that the M88A1E1's slower speed would leave it far behind the armored force and therefore hinder its ability to rapidly recover tanks.

According to Army officials, the vehicle testing was conducted under conditions the Army believes approximate those found in Germany. More specifically, Army models project that if a recovery vehicle can negotiate a 30-percent slope with a tank in tow under the prescribed soil hardness conditions, it can negotiate 90 percent or more of the terrain likely to be found in Germany. The M88A1E1 failed a test on a 27-percent slope. However, an Army representative stated that prescribed soil hardness conditions were not properly controlled to ensure that they conformed to the system's specification. BMY believes that the soil was softer than called for in the Army's requirement and that its vehicle would have accomplished the task had the Army properly controlled and documented test conditions.

The Army has not conducted a COEA, which might have addressed the issue of operational effectiveness from the perspective of vehicle speed and towing. In 1985, Army management directed the project office not

to perform a COEA because the program involved a product improvement and therefore did not require a COEA. Later, however, in November 1988, the Army reassessed its direction and determined that a COEA was required. The project office had not started the study before DOD proposed termination of the program.

Vehicle Quantities and Cost

Currently, DOD proposes terminating the program because of budget considerations and questionable performance. Before this proposal arose, the Army's Authorized Acquisition Objective was for 849 recovery vehicles. The Army planned to buy 276 vehicles at an estimated cost of $416.3 million through fiscal year 1994.

Conclusions

The question of how fast a recovery vehicle should go has been an ongoing issue since 1985. The SSEB raised concerns about procuring a vehicle that may not be able to keep up with tank battalions under certain conditions. In spite of its shortcomings, however, the modified M88A1E1 could provide additional capability over the current fielded model, which cannot perform some important tasks. For example, the new version may enable recovery units to tow with only one vehicle, while in some situations the old version requires two.

BMY believes that the uphill towing phase of the Army's tests was not carefully controlled, and therefore there is uncertainty over the M88A1E1's towing capabilities on some inclines. In addition, the Army had not yet performed the required COEA, which may help to resolve the questions about speed raised by the SSEB.

Recommendations

We recommend that, in any future program to meet the Army's need for improved tank towing capabilities, the Secretary of the Army ensure that test conditions are carefully controlled and documented and that any required COEA be conducted on a timely basis.

As requested, we did not obtain official agency comments on this report. However, we discussed its contents with the Improved Recovery Vehicle Program Office, Army Headquarters, and DOD officials, and they concurred with the report findings. We also incorporated several specific changes where appropriate.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time,

we will send copies to the Chairmen, Senate Committee on Governmental Affairs, Senate and House Committees on Armed Services, and Senate and House Committees on Appropriations, and the Secretaries of Defense, the Army, the Navy, and the Air Force.

GAO staff members who made major contributions to this report are listed in appendix III.

Sincerely yours,

Richard Davis

Richard Davis
Director, Army Issues

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Abbreviations

COEA	Cost and Operational Effectiveness Analysis
DOD	Department of Defense
GAO	General Accounting Office
GDLS	General Dynamic Land Systems
SSEB	Source Selection Evaluation Board
TRADOC	Training and Doctrine Command
WES	Waterway Experimental Station

The Army's Evaluation and Testing of Candidates for the Tank Recovery Vehicle

Source Evaluation Process and Results

The Army rated the two competing systems in six areas. In descending order of priority these were technical performance, operational suitability, cost, man/machine interface, logistics, and production capability. A Source Selection Evaluation Board (SSEB) evaluated the two systems in these areas using data from two sources: (1) the side-by-side test and (2) contractor information provided in response to the Request for Proposal. Although both recovery vehicles met the Army's requirements, each demonstrated shortcomings. According to the Army's test results, the General Dynamics Land Systems (GDLS) vehicle had winching problems and degraded towing ability under some conditions because of poor traction and/or poor positioning of its tow-bar mounting bracket. BMY's vehicle demonstrated performance problems in the areas of winching, speed, engine/transmission cooling, and uphill towing. Table 1.1 shows the SSEB's summary rating.

Table I.1: SSEB Evaluation Results

Criterion	BMY	GDLS
Technical performance	Adequate	Excellent –
Operational suitability	Adequate	Adequate +
Cost	Adequate	Adequate
Man/machine interface	Adequate +	Adequate
Logistics	Excellent	Excellent +
Production capability	Adequate	Excellent
Overall score	Adequate	Adequate

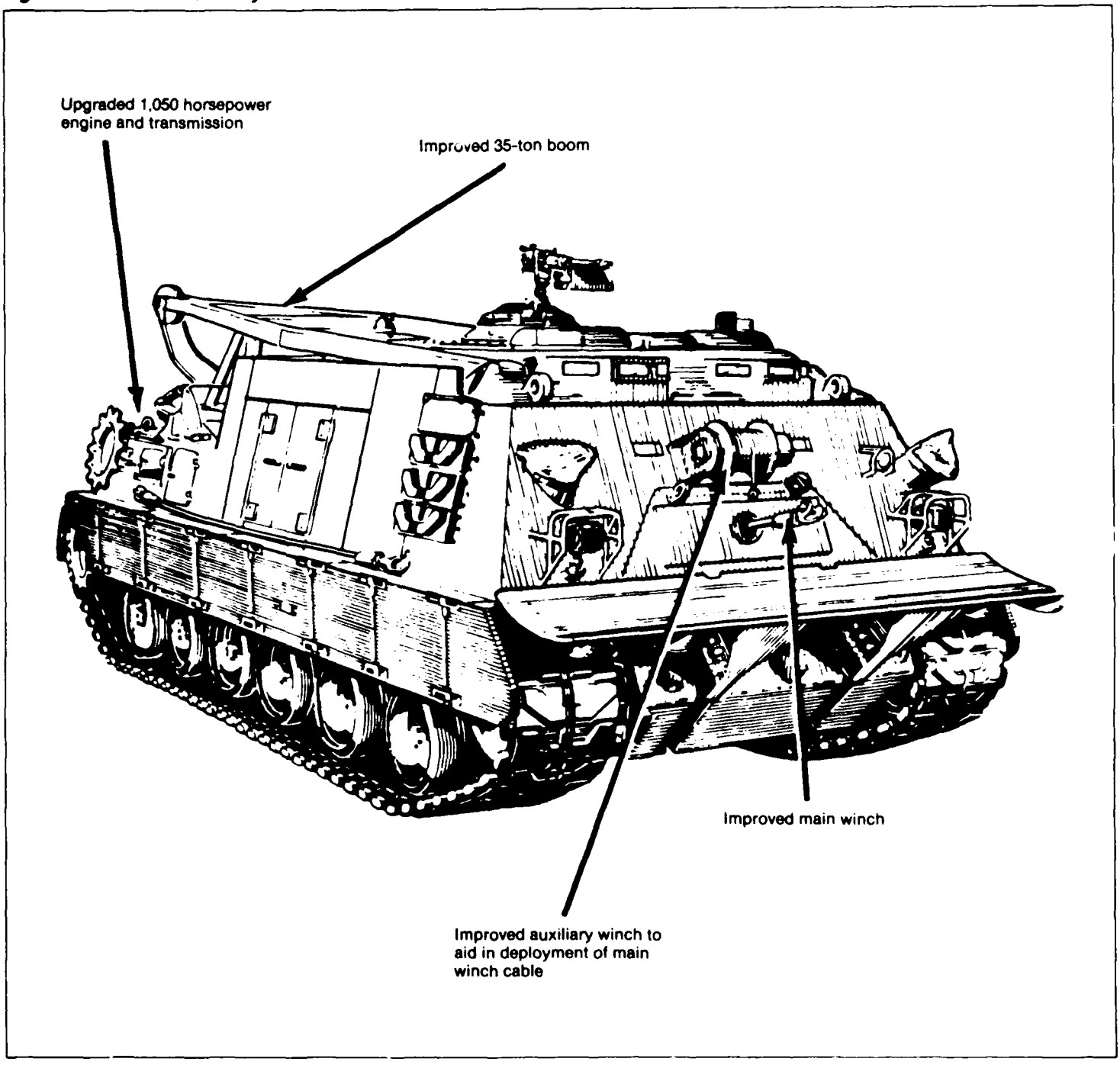
Note: The SSEB's assessments included minuses and pluses in some areas, indicating relatively stronger or weaker performances in those areas

The results of the SSEB's evaluation were provided to the designated Army Source Selection Authority in August 1988. The Source Selection Authority selected the BMY system in September 1988 because the differences in performance offered by the GDLS vehicle were judged insufficient to compensate for its much higher cost over the BMY system. GDLS proposed an average unit cost of about $2.2 million, while BMY's proposed unit cost averaged about $1.2 million. Figure I.1 shows BMY's vehicle—the M88A1E1—and its major components. The system's deficiencies are discussed in more detail below.

M88A1E1 System's Deficiencies

While the Army determined that BMY's vehicle will essentially meet its requirements for a recovery vehicle, it identified a number of deficiencies requiring correction as a result of the side-by-side tests. Citing concern over these deficiencies, the Army decided to extend full-scale

Figure I.1: M88A1E1 Recovery Vehicle



engineering development to correct the problems before making a decision on production. Table I.2 shows the deficiencies and corrective actions.

Table I.2: System Deficiencies Requiring Corrective Action

Deficiency	Corrective action
Main and auxiliary winches	
Auxiliary winch did not have sufficient pull to deploy the main winch, and the auxiliary winch could not be controlled to match the main winch's speed.	BMY is installing a more powerful auxiliary winch.
The main winch cable could not be deployed and retrieved by only one soldier.	BMY is integrating a levelwind and tension device.
Auxiliary winch was not protected by armor.	BMY is developing an armor enclosure for the auxiliary winch.
The controls for the main and auxiliary winches were hard to operate.	BMY is relocating the winch control valve to provide improved access to the controls.
Cooling system	
The engine and transmission overheated.	BMY is modifying the cooling system by adding a new cooling shroud to improve the cooling airflow across the engine and the transmission oil coolers.
Reliability	
The vehicle experienced excessive final drive failures.	BMY identified a quality control problem and took corrective action.
Uphill towing	
The vehicle did not pass the off-road 30-percent slope test.	No corrective action has been taken. BMY's position is that the current configuration will meet the Army's requirements if the tests are properly controlled and documented.

Deficiencies in the Main and Auxiliary Winches

One problem with the BMY vehicle identified during the side-by-side test dealt with the main and auxiliary winch system. To deploy the main winch, the M88A1E1 uses an auxiliary winch to draw out the heavier main winch cable to the point where it is connected to the tank. The Army found numerous deficiencies with the main and auxiliary winch system, including the following:

- The vehicle had inadequate power to deploy the main winch.
- Controls for the main and auxiliary winches were hard to operate.
- The auxiliary winch's speed was inadequately controlled relative to the main winch's speed. This mismatch resulted in the winches' cables becoming tangled.
- The armor protection for the auxiliary winch was inadequate.

The Army, as a precondition to starting additional testing later in the full-scale engineering development period, required that BMY correct

the main and auxiliary winches' deficiencies and successfully demonstrate that the changes had corrected the problems. BMY's modifications include incorporating a more powerful auxiliary winch, integrating a level wind mechanism that coordinates the main and auxiliary winches' speeds, simplifying the control system, and developing an armored auxiliary winch enclosure. According to the program manager, BMY was able to demonstrate that winch modifications made or proposed would solve the problems. Complete technical testing, the results of which would have provided the Army with needed data for making a production decision, was started in March 1989 but was stopped in May 1989.

Engine Cooling Problems

According to Army evaluators, the M88A1E1 only marginally met the system specification mobility requirements because the engine oil temperatures were too high. While the M88A1E1 met the system's requirements for sustained speed with and without towed loads, the engine's oil temperatures at those speeds exceeded the Army's operating temperature limits for lubricating oils. The Army, after adjusting the vehicle's speed performance through a series of mathematical computations to compensate for the overheated oil condition, determined that the vehicle would have sustained only 23.0 mph without the towed load and 11 mph with the towed load. This computation was performed to give the evaluators a better picture of the vehicle's speed under approved oil operating temperatures. In table I.3, the actual speeds the vehicle attained are compared to the speeds required in the system's specification.

Table I.3: M88A1E1 Speed Test Results

Figures in miles per hour

Requirement	Criteria	Actual	Adjusted
Sustained speed			
Without towed load	25	25.0	23.0
With towed load	13	16.6	11.0
Maximum speed			
With towed load	17	16.6	16.6

BMY, in conjunction with its engine manufacturer, developed a modified engine and transmission cooling package to improve cooling airflow across the engine and transmission oil coolers.

Reliability

During the side-by-side test, several seals in the M88A1E1's final drive units leaked. BMY was able to trace the problem to bolt threads coming

into contact with portions of the seal, resulting in fraying. The part is now modified to prevent recurrence of the problem.

Uphill Towing

The M88A1E1 did not pass a system requirement that it tow a 70-ton tank up a 30-percent unpaved slope under prescribed soil hardness conditions. BMY questioned the test results because the Army had failed to properly measure and document the soil hardness for the test. Thus, the soil conditions might not have conformed to the hardness index specified in the system specification. This issue is discussed in more detail in the test realism section.

M88A1E1's Speed Questioned

An issue potentially affecting the M88A1E1's ability to effectively meet the Army's mission needs for a recovery vehicle is its speed. The SSEB raised questions concerning the vehicle's ability to keep pace with the forces it is to support as well as to effectively recover disabled tanks.

This is not a new issue, since the Army—in selecting the product-improved M88A1E1 recovery vehicle option over a new RV-90 recovery vehicle in 1985—reduced its speed requirements for the recovery vehicle. The RV-90 offered higher speeds, which would have enabled it to keep up with the Abrams tank. However, in part due to cost and scheduling considerations, the Army elected to go with the lower speeds provided for in the product-improved recovery vehicle.

The M88A1E1 prototype came close but did not meet the Army's sustained speed requirements with and without a towed load. The SSEB's operational suitability assessment raised concerns about the vehicle's ability to support the combat force. The SSEB's report stated that the vehicle's convoy speed would limit its ability to keep up with the Abrams tank force it was designed to support during convoys, high-speed penetrations, or lateral movements and that the more mobile and agile combat force would leave the recovery vehicle lagging far behind the supported force, thereby limiting its ability to rapidly recover disabled tanks. Further, the SSEB's report concluded that, while the M88A1E1 can tow a 70-ton load, it exhibited only a marginal improvement in speed over the older M88A1. The SSEB considered the towing speed of 17 mph only marginally adequate to support today's Abrams-equipped armored force. The marginal towing speed increased the time the vehicle and crew were exposed to enemy fire and impacted on the time it took to recover damaged tanks.

Test Realism

The side-by-side tests were conducted at the Army's Aberdeen Proving Grounds in Maryland where the Army has attempted to approximate ground and terrain conditions generally found in Germany. The test conditions ranged from level terrain to steep slopes and from soft to extremely hard soil. Tests were also conducted on both paved and unpaved roads.

The one test issue had to do with the Army's control and documentation of test slope conditions in determining compliance with the uphill towing requirements. The Army's system specifications required that the recovery vehicle demonstrate the capability to tow a 70-ton tank up 10-, 20-, and 30-percent slopes on paved roads and cross-country on similar slopes under predetermined soil hardness conditions. The U.S. Army Waterway Experimental Station (WES), Corps of Engineers, maintains computerized models of the different types of terrain and ground conditions found in Germany. A WES official stated that the WES models indicate that if a recovery vehicle can tow a tank up a 30-percent slope at the soil hardness levels provided in the recovery vehicle system specification, it can negotiate 90 to 93 percent of the slopes in Germany.

On paved surfaces, the BMY vehicle was able to satisfy the towing requirement. However, under secondary road/cross-country conditions, the vehicle towing a 70-ton tank was unable to climb a 27-percent slope. The Army and the contractor disagree about the causes. BMY officials say that the test conditions were not properly controlled because the Army's testers failed to take the proper measurements to determine specified soil hardness. The Army's test director agrees that the ground hardness was not properly controlled. However, he believes that, because there had been a lack of rain, the ground was extremely hard and probably exceeded the conditions prescribed in the requirements. BMY believes, however, that, while the ground in general might have been relatively hard, the soil at the start of the slope was softer due to prior tracked vehicle traffic and that this softer soil prevented its vehicle from climbing the hill. BMY believes that the M88A1E1 as currently configured will meet the Army's towing requirements if the test is properly controlled.

Objectives, Scope, and Methodology

Our objective was to review the Army's Improved Recovery Vehicle acquisition program. Specifically, we sought to determine (1) what selection criteria the Army used to make its vehicle selection; (2) whether the M88A1E1 vehicle selected, which was developed by BMY, a Division of HARSCO Corporation, meets the Army's recovery requirements, as stated in its contract specifications; (3) whether the Army's requirements are stringent enough to meet its mission needs; (4) whether the comparative side-by-side tests of the two alternative recovery vehicle candidates were performed under realistic conditions; and (5) how many M88A1E1s the Army plans to buy and how much it plans to spend.

In performing our work, we reviewed the Army's acquisition plans; its recovery vehicle requirements; Request for Proposal DAAE07-88-R-R105, dated June 15, 1988; test plans; and test reports, including independent agency evaluation reports and the Army SSEB's report.

We interviewed the Army personnel who had developed the requirements, conducted the side-by-side tests, and managed the program. We interviewed officials in U.S. Army, Europe, headquarters and field battalion soldiers using the current M88A1. We also held discussions with top management officials at the BMY Corporation, the builders of the M88A1E1. Further, we evaluated the technical and operational test results and other available documentation.

As requested, we did not obtain agency comments on this report. However, we discussed the results of our analysis, as well as other information, with U.S. Army Tank-Automotive Command program management, Department of the Army, and DOD officials.

We conducted our review from February through April 1989 in accordance with generally accepted government auditing standards.

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